Real-Time Applications of Direct Broadcast Data from Aqua and Terra

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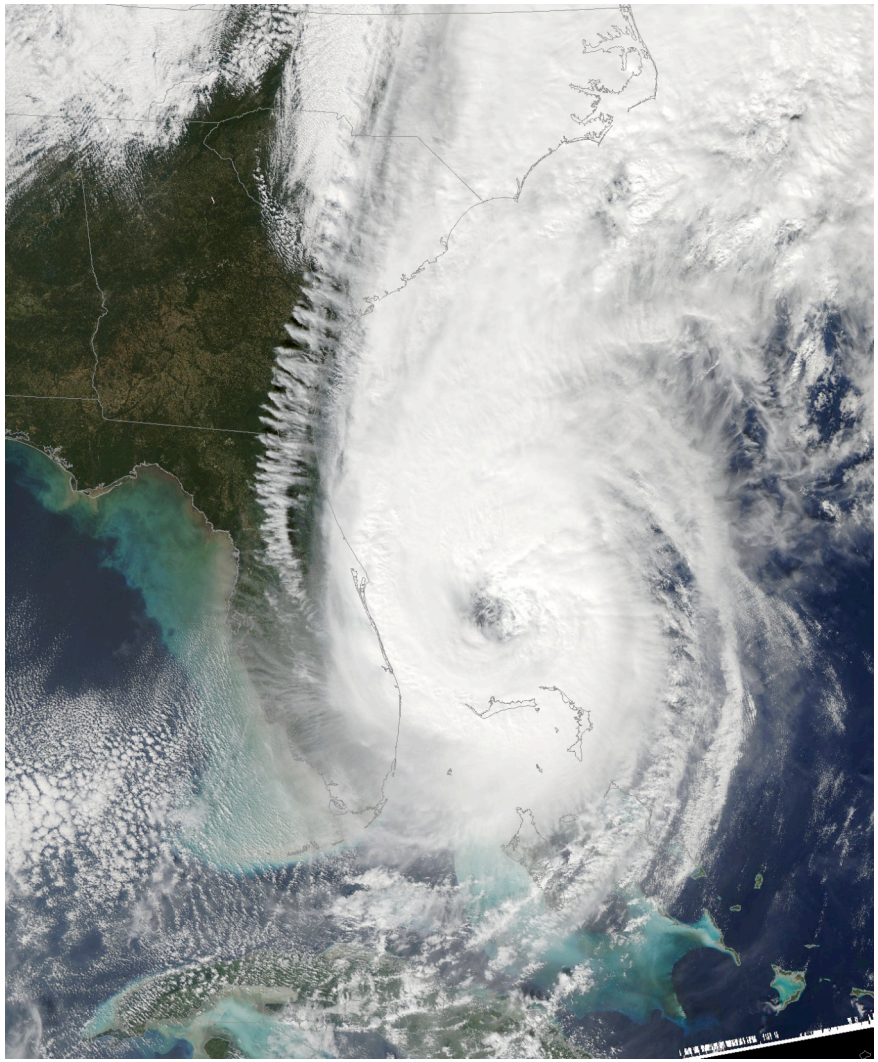
Kathy Strabala

Space Science and
Engineering Center

University of Wisconsin-
Madison

25 October 2006
Polar Max 2006



Hurricane Wilma, 24 Oct. 2005, Aqua DB

Image Credits

V. Gershenzon and A. Shumilin, ScanEx Moscow

C. Smith, ACRES

J. Key, NOAA/NESDIS

K. Strabala, UW/CIMSS

G. Cabrera, CONAE

G. Jedlovec, NASA/MSFC

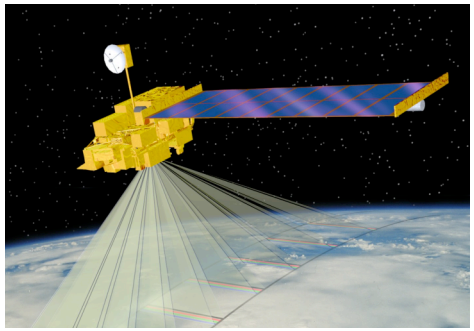
R. DeAbreu, CIS

G. Leshkevich, NOAA/GLERL

Q: What is Direct Broadcast (DB)?

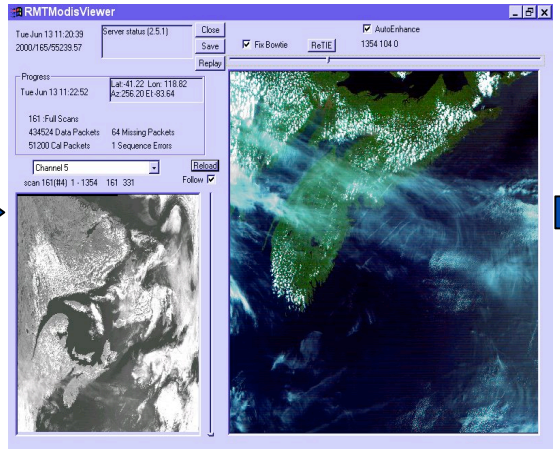
A: Transmission of Earth Observations from Satellite to Ground Station in Real-Time

Satellite

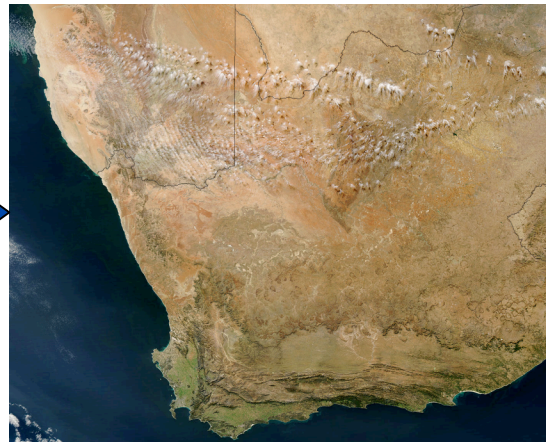


- For Terra and Aqua, signal is unencrypted and freely available (no license required)
- Processing software is freely available
- All aspects of ground processing, product development, and data distribution are under local control

Ground Station



Processing Software



Products and Applications

Terra

Launched: Dec. 18, 1999

10:30 am descending

ASTER: Hi-res imager

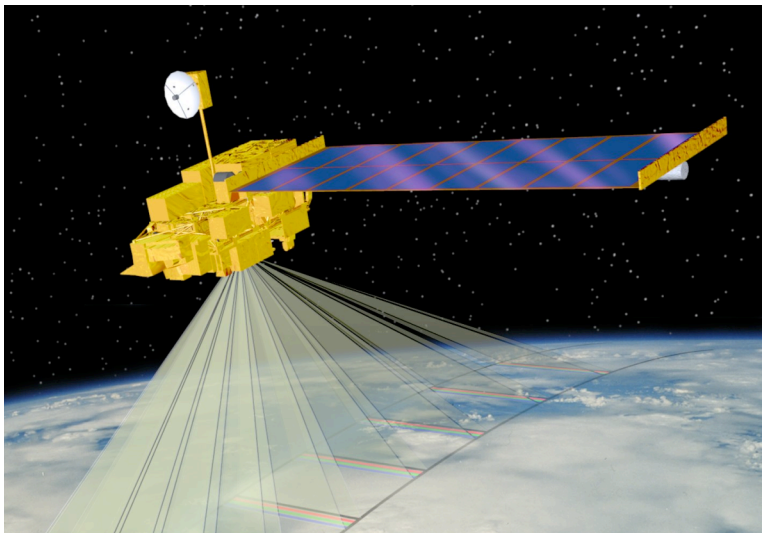
CERES: Broadband scanner

MISR: Multi-angle imager

MODIS: Multispectral imager

MOPITT: Limb sounder

Only MODIS is available by DB



Aqua

Launched: May 4, 2002

1:30 pm ascending

AIRS: Infrared sounder

AMSR-E: Microwave scanner

AMSU: Microwave scanner

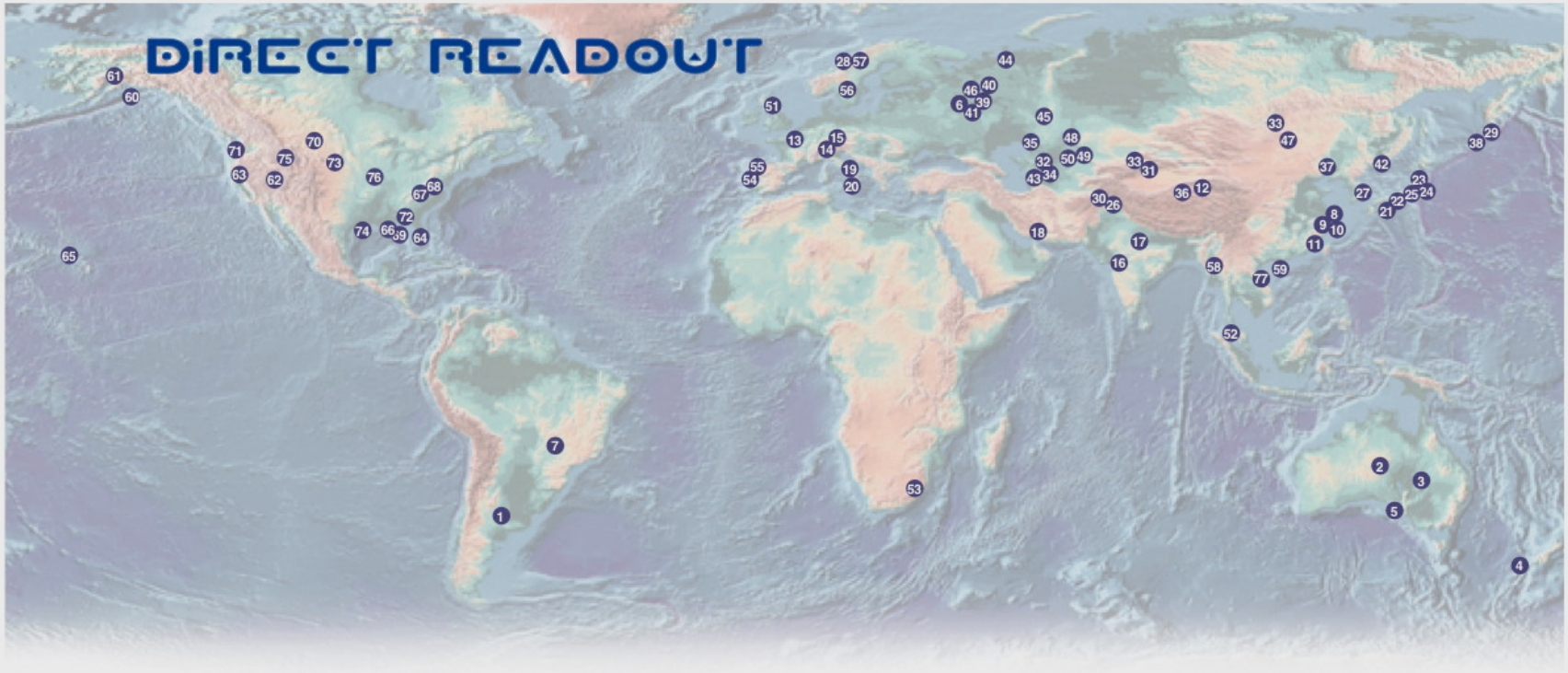
CERES: Broadband scanner

HSB: Microwave sounder

MODIS: Multispectral imager

All sensors are available via DB

EOS Direct Broadcast Sites



More than 150 ground stations around the world

(not all are shown on this map from Nov. 2003)

北京
Beijing

Moscow
27/11/03 12:58

Madison

Benevento

Advantages of DB:

- Facilitates access to advanced sensors, precursor to NPP/NPOESS
- Local control and autonomy gives users freedom to tailor operations
- Timeliness for responding to natural hazards and providing information for decision makers.
- Local researchers are free to develop and refine algorithms tuned for local conditions

Direct Broadcast Applications described in this presentation:

Ice Monitoring
Bushfire Detection
Weather Forecasting
Polar Winds

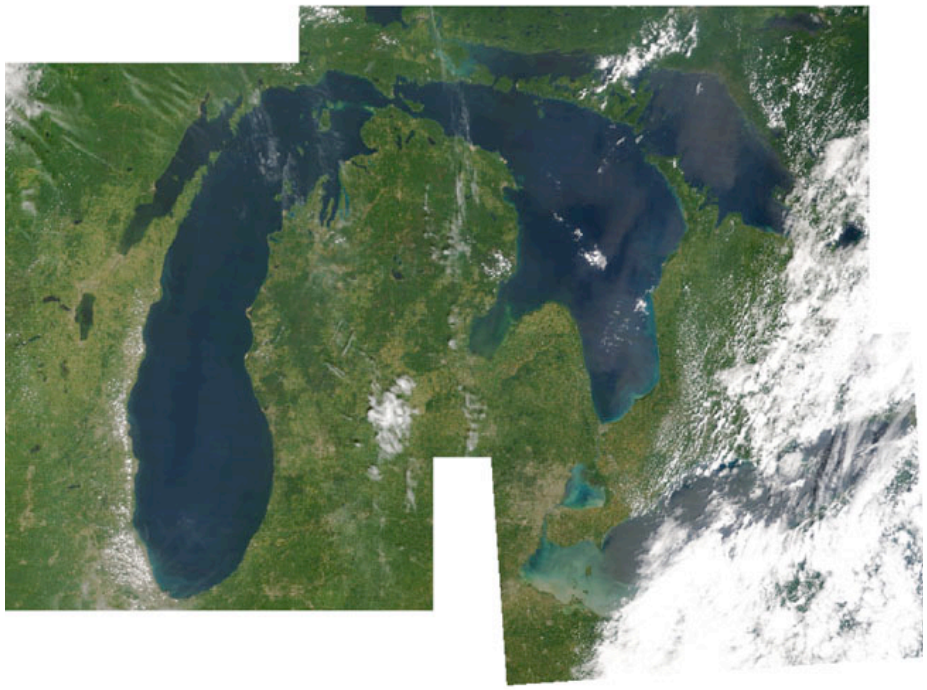
Application:
Ice Monitoring

Realtime MODIS GeoTIFF products Ice Monitoring

Aqua and Terra MODIS 250 meter true color images are produced daily at SSEC for each of the Great Lakes, Hudson Bay, and Northeast Canada.

GeoTIFF format in UTM projection (GIS compatible).

NOAA Coastwatch, National Ice Center, and Canadian Ice Service download the images in realtime.



NOAA Great Lakes CoastWatch

http://coastwatch.glerl.noaa.gov/

"canadian ice service" mc

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What's New
CW Overview

AVHRR Imagery
GLSEA
Contour Maps
GOES Imagery
RADARSAT
MODIS Imagery
Ocean Color
Image Products
In Situ Data
GLFS
Statistics

JAVA GIS
Image Archive
Software
Documentation
Validation

Welcome to the NOAA CoastWatch Great Lakes Node

CoastWatch

Great Lakes CoastWatch Node
NOAA/Great Lakes Environmental Research Laboratory
2205 Commonwealth Blvd.
Ann Arbor, MI 48105-2945
Fax: 734-741-2055
http://coastwatch.glerl.noaa.gov

George A. Leshkevich, *Manager*

Songzhi Liu, *Operations Assistant*

CoastWatch Great Lakes Map

http://coastwatch.glerl.noaa.gov/modis/region_map.html

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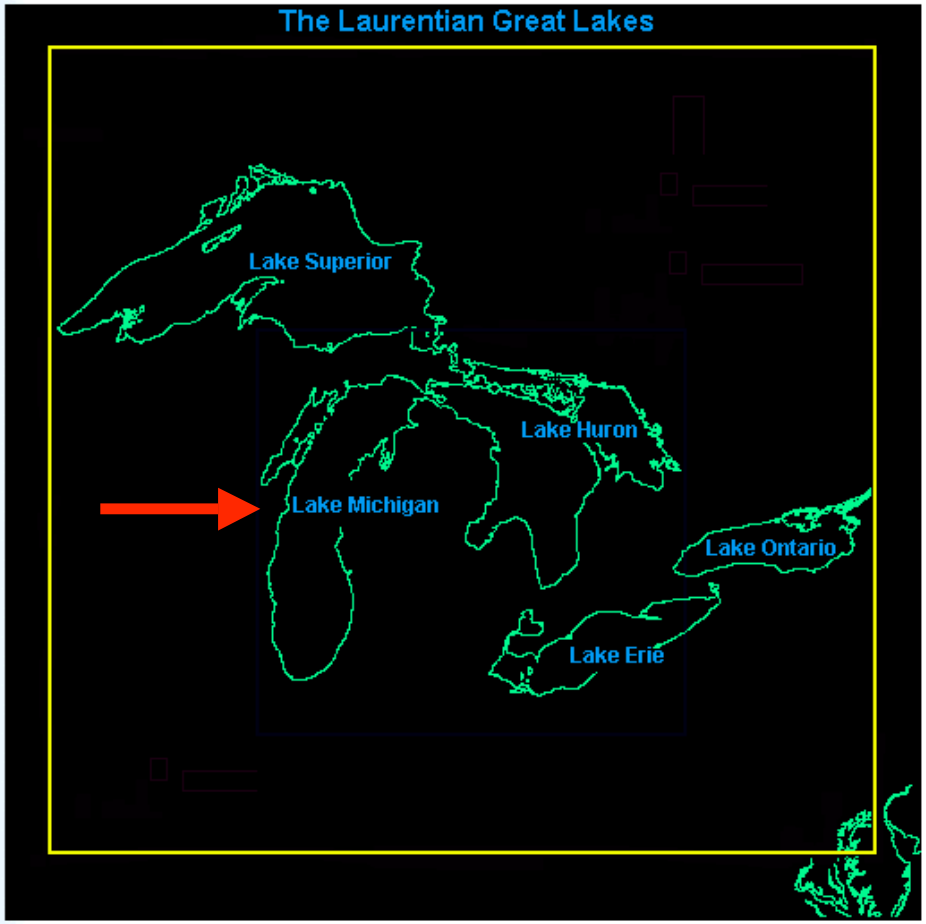
Disclaimer

Home > Region Map



Lake Superior
Lake Michigan
Lake Huron
Lake Erie
Lake Ontario

click in map or links

For current MODIS imagery, click in region of interest

MODIS data acquired by direct broadcast and processed at the Space Science and Engineeering Center, University of Wisconsin-Madison

Lake Michigan MODIS Imagery

http://coastwatch.glerl.noaa.gov/modis/modis.cgi/modis?region=m&page=1

"canadian ice service" modis

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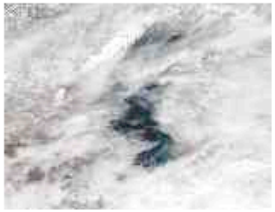
Home > Region Map > Lake Michigan

NOAA CoastWatch - Great Lakes Region

Lake Michigan MODIS Imagery - True Color, 250 m Resolution

Current time: 03/24/2005 14:17:55 GMT

Page: 1 of 4 1 2 3 4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03/23/2005 16:38 GMT

03/22/2005 19:12 GMT

03/22/2005 17:33 GMT

03/22/2005 15:56 GMT

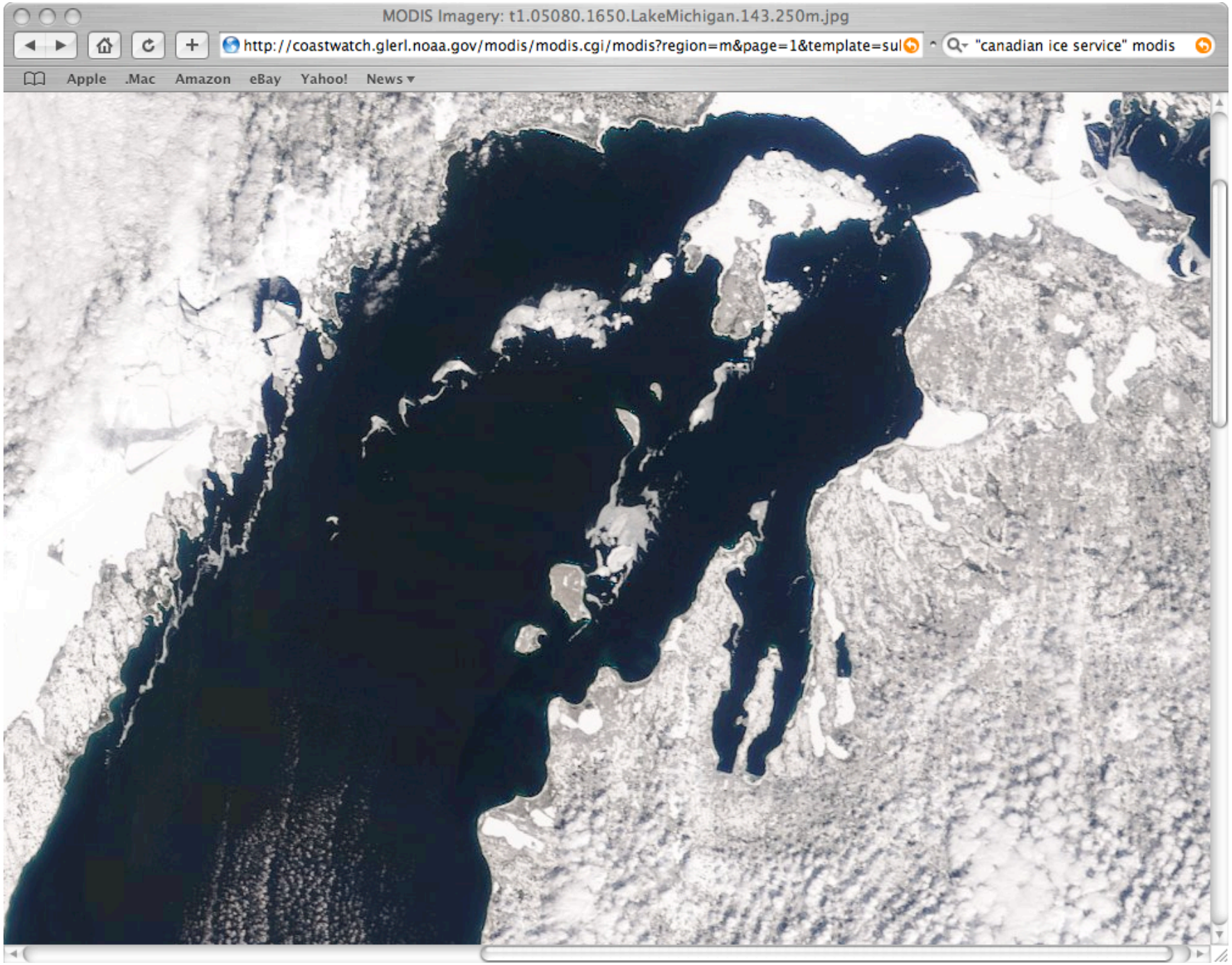
03/21/2005 18:29 GMT

03/21/2005 16:50 GMT

03/20/2005 19:24 GMT

03/20/2005 16:08 GMT

MODIS data acquired by direct broadcast and processed at the Space Science and Engineeering Center, University of Wisconsin-Madison


MODIS Imagery: t1.05080.1650.LakeMichigan.143.250m.jpg
http://coastwatch.glerl.noaa.gov/modis/modis.cgi/modis?region=m&page=1&template=sul
"canadian ice service" modis
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.Mac
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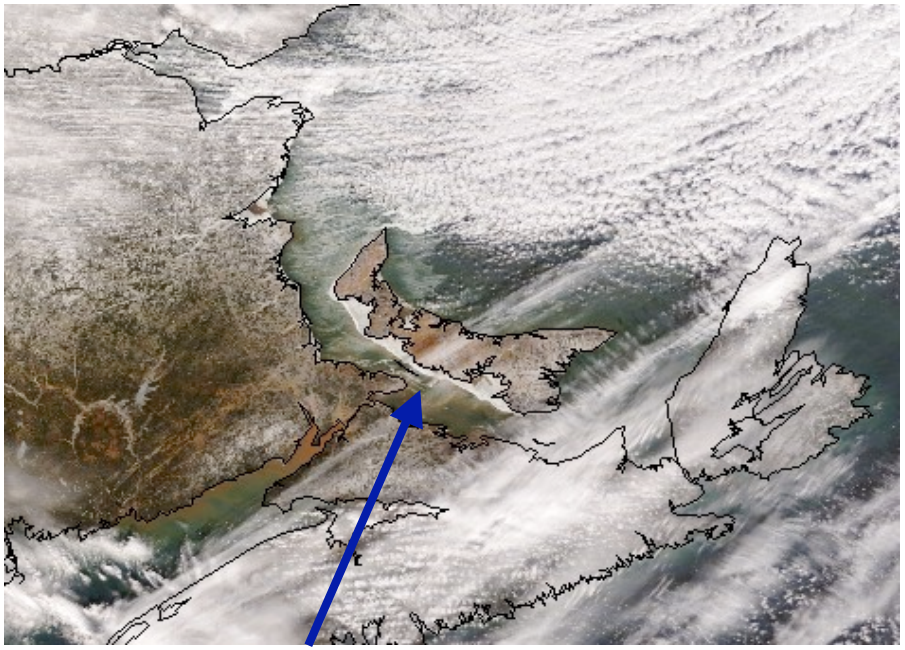
News

Canadian Ice Service integrates MODIS into operational data stream for ice monitoring

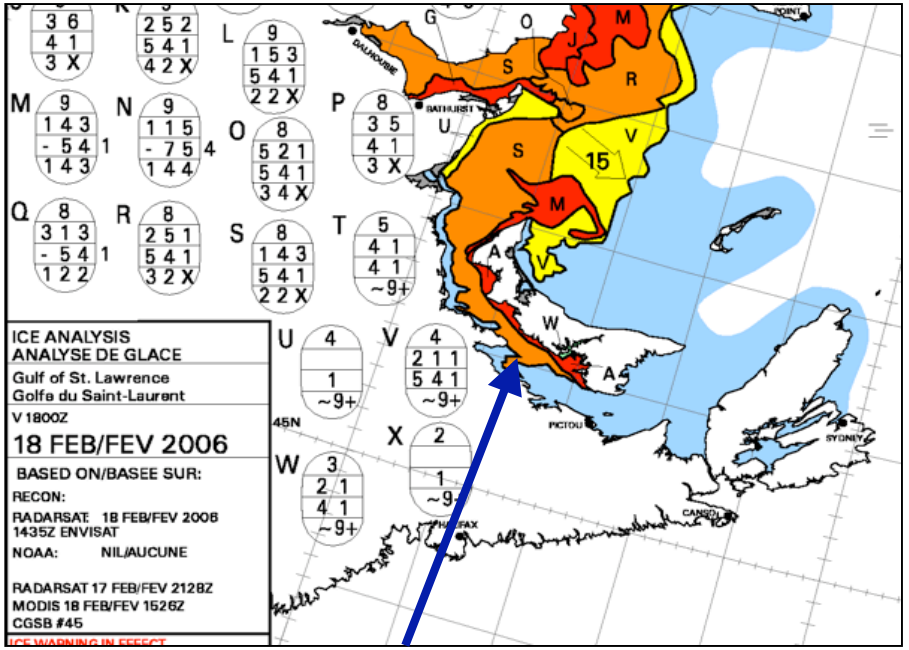
CIS data suite includes RadarSat and Envisat (SAR); AMSR, QuikScat and SSM/I (microwave); MODIS, OLS, NOAA and GOES (visible images).

- MODIS supplements SAR data in clear sky conditions.
- 250 meter resolution true color GeoTIFF images are obtained daily from SSEC for Great Lakes, Hudson Bay, Labrador coast, and Gulf of St. Lawrence.

MODIS helps to define ice boundary along southern Prince Edward Island



MODIS DB image 2006/02/18 15:26 UTC



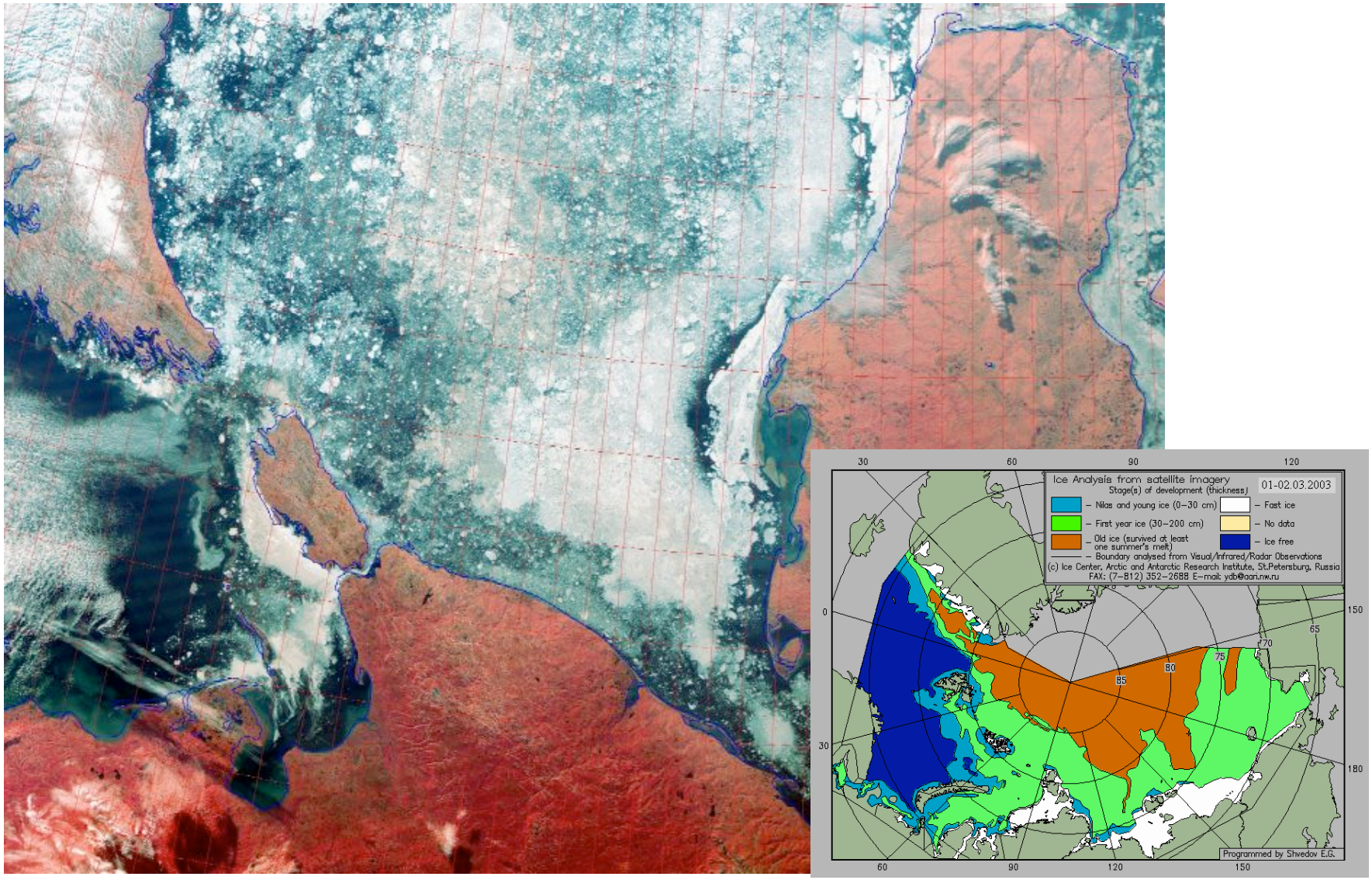
CIS Ice Analysis 2006/02/18

СканЭкс
ИНЖЕНЕРНО-ТЕХНОЛОГИЧЕСКИЙ ЦЕНТР

The network of EOScan™ ground stations for MODIS data acquisition

СканЭкс
ИНЖЕНЕРНО-ТЕХНОЛОГИЧЕСКИЙ ЦЕНТР

Operational sea ice monitoring

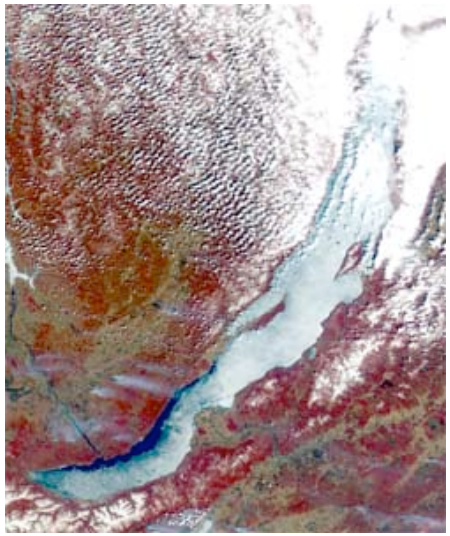
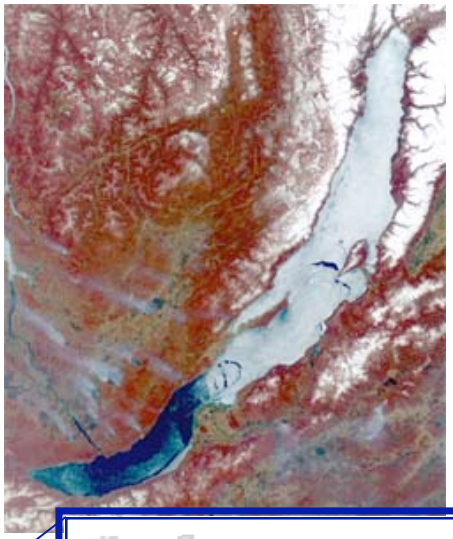


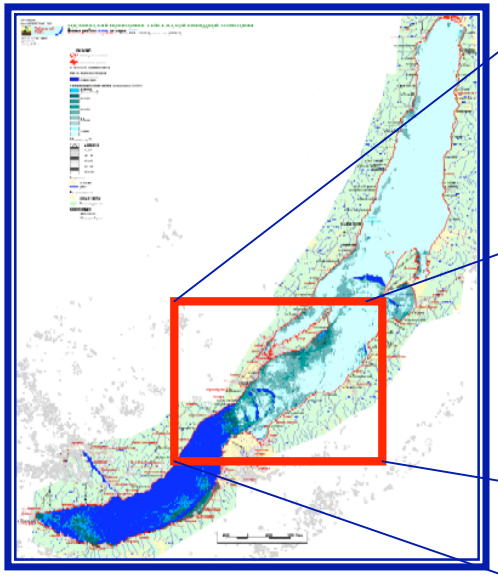
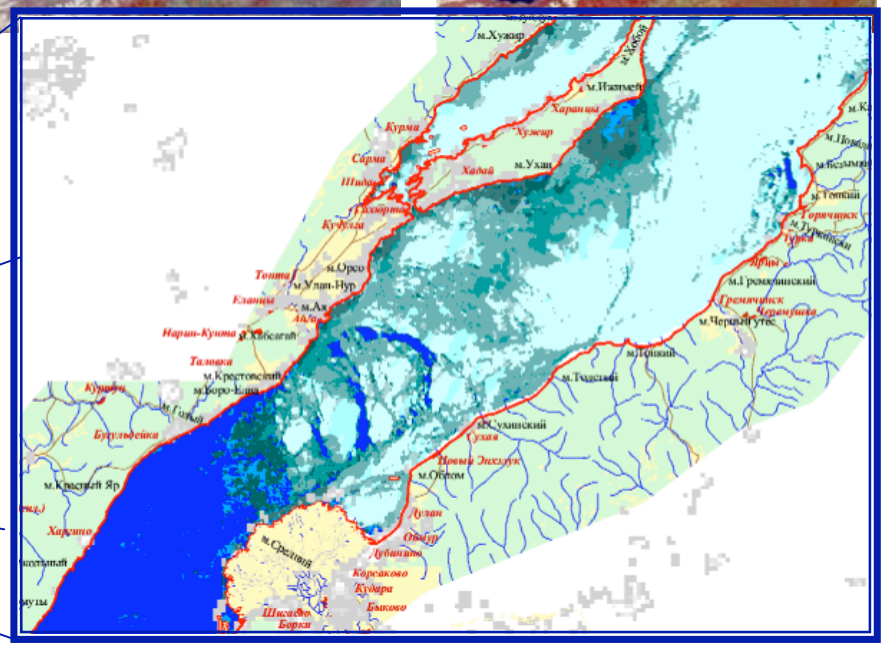
Arctic and Antarctic Research Institute (St.Petersburg) supplies weekly ice charts using data from NOAA-*, Terra and Meteor-3M satellites.

СканЭкс
ИНЖЕНЕРНО-ТЕХНОЛОГИЧЕСКИЙ ЦЕНТР

Lake Baikal lake ice monitoring (Irkutsk DB station)

2003-05-02 2003-05-06 2003-05-19

Application:
Bushfire Detection

Sentinel Hotspots:

Joint project developed Department of Defence, CSIRO and Geoscience Australia

Sentinel Hotspots is an internet-based mapping tool designed to provide timely fire location data to emergency service managers across Australia

ACRES MODIS Data from Geoscience Australia

Geoscience Australia provides online Near Real Time (NRT) ACRES MODIS data from Terra & Aqua.

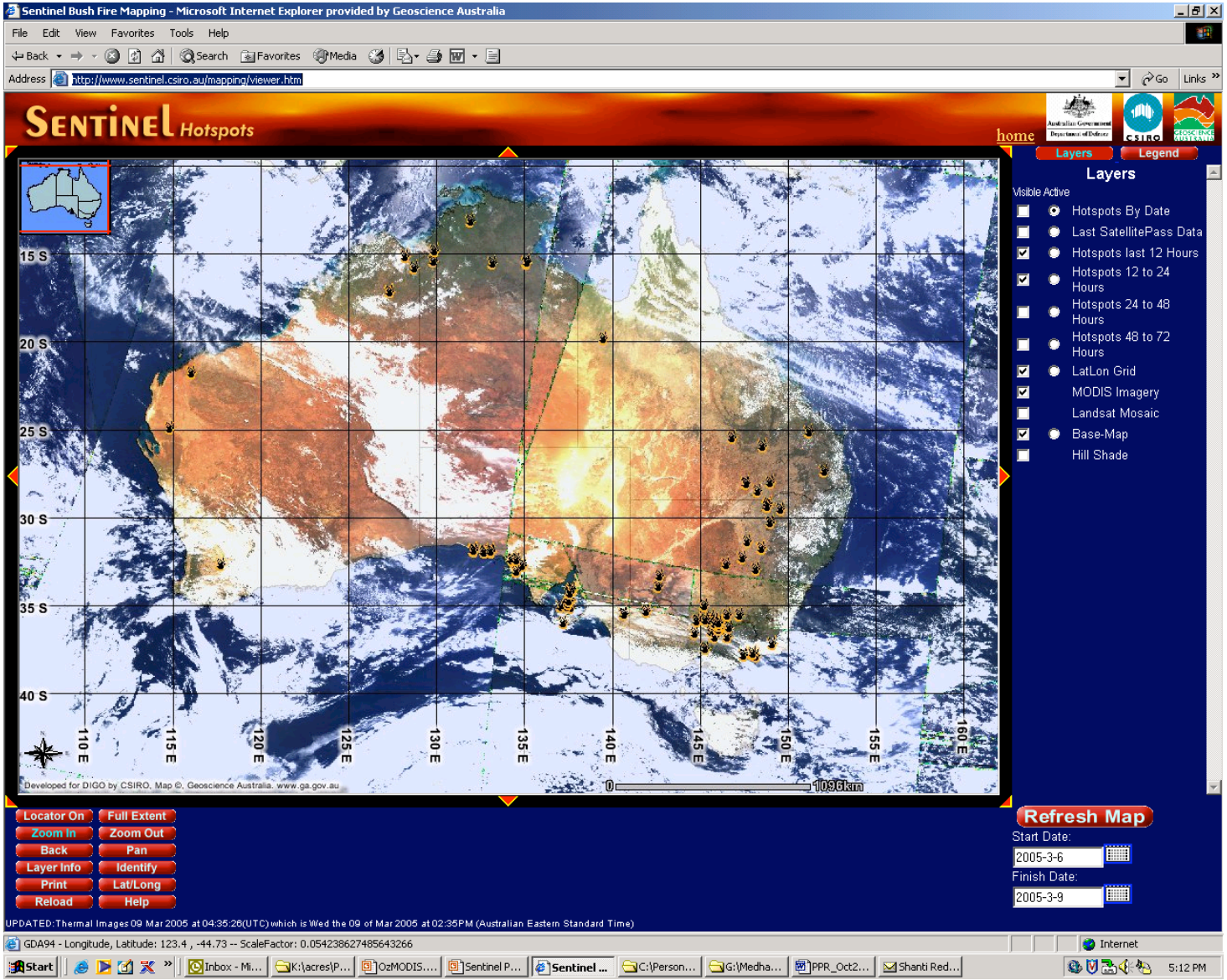
ACRES MODIS products are available in satellite path orientation (Level 1B), or map oriented (Lambert Conformal projection).

MODISL1DB is used to generate ACRES MODIS Level 1B NRT data.

ACRES MODIS map oriented products are generated using MRTSwath.

Sub pixel registration of multi-temporal ACRES MODIS Terra map oriented products is being achieved on a consistent basis.

Sentinel Hotspots
(Department of Defence, CSIRO & Geoscience Australia)



http://www.sentinel.csiro.au/mapping/viewer.htm

Jan. 2005 Case Study

Fire hotspot mapping

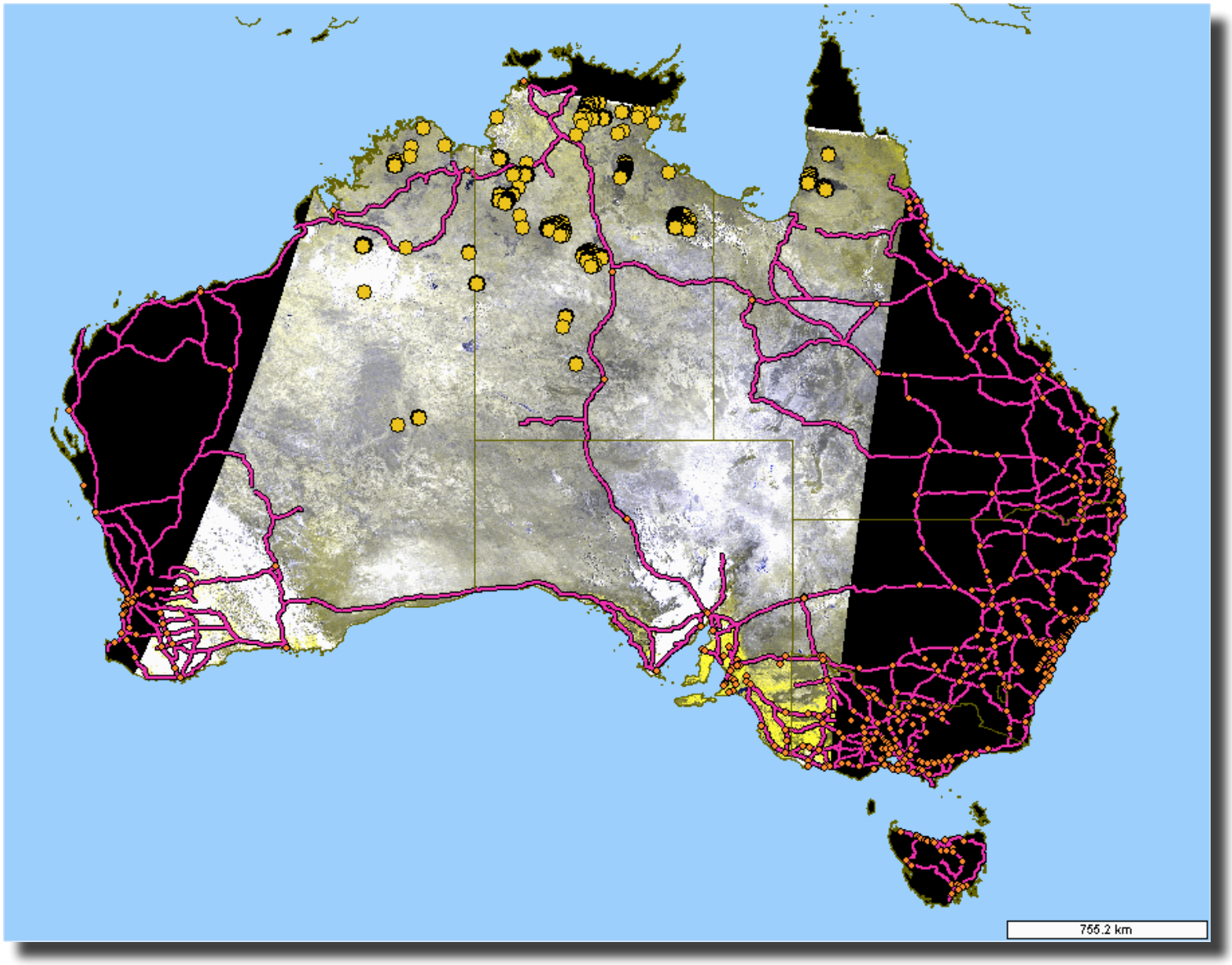
- On 11 Jan. 2005 a major fire emergency took place on the Eyre Peninsula in South Australia, killing 9 people.
- Sentinel was used in fire-fighting operations to help prevent even greater loss of life and property destruction
- Over the past several years, in numerous fire emergencies, Sentinel Hotspots has come to be relied upon by fire fighting agencies nationwide.

The Sentinel Fire Mapping website is regarded as a service of National Significance.

Near Real Time Hotspots and Images for Burnt Area, Smoke and Cloud Identification

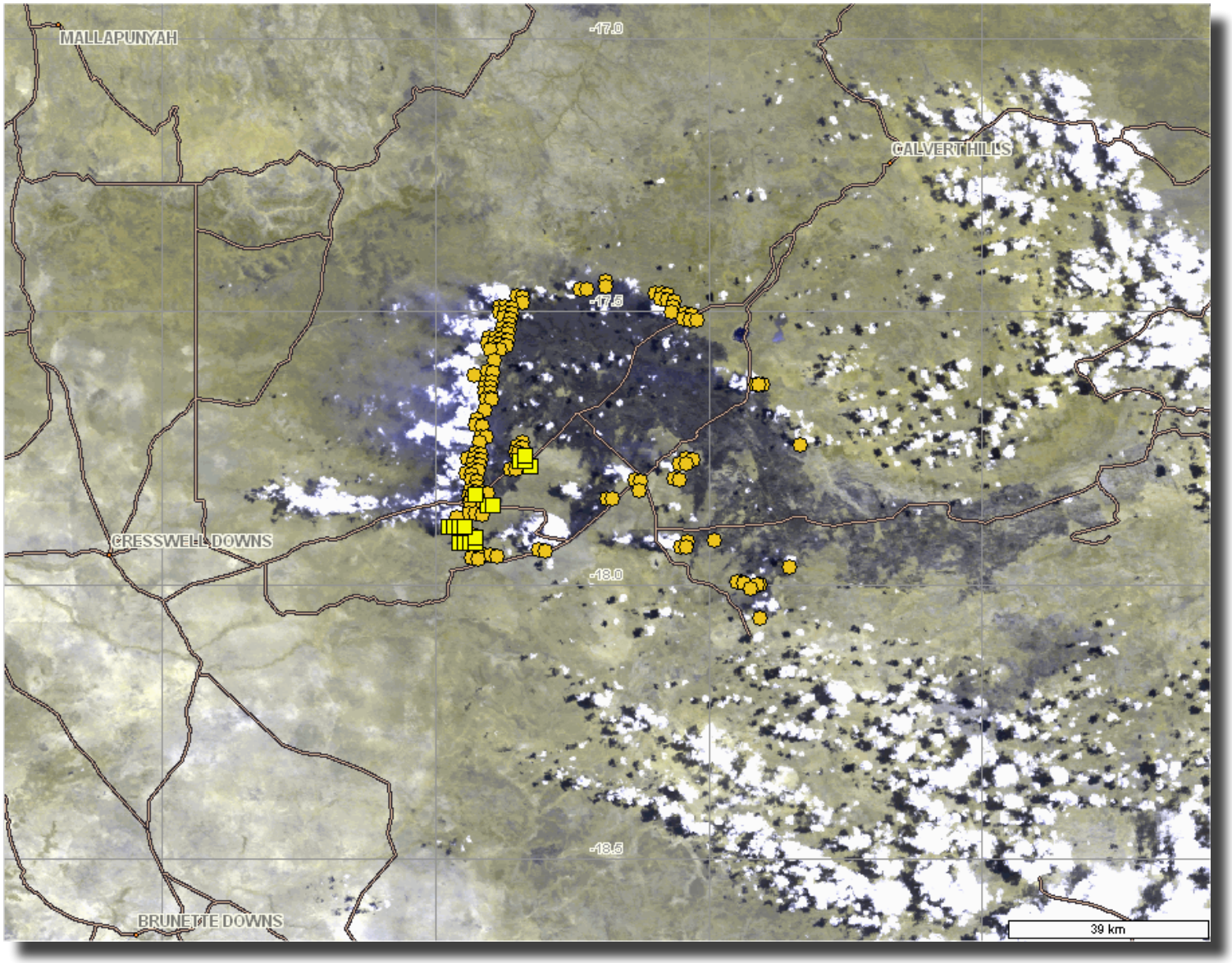
available on-line within 1h of acquisition

06/10/04
09:20WST



Near Real Time Hotspots and Images for Burnt Area, Smoke and Cloud Identification

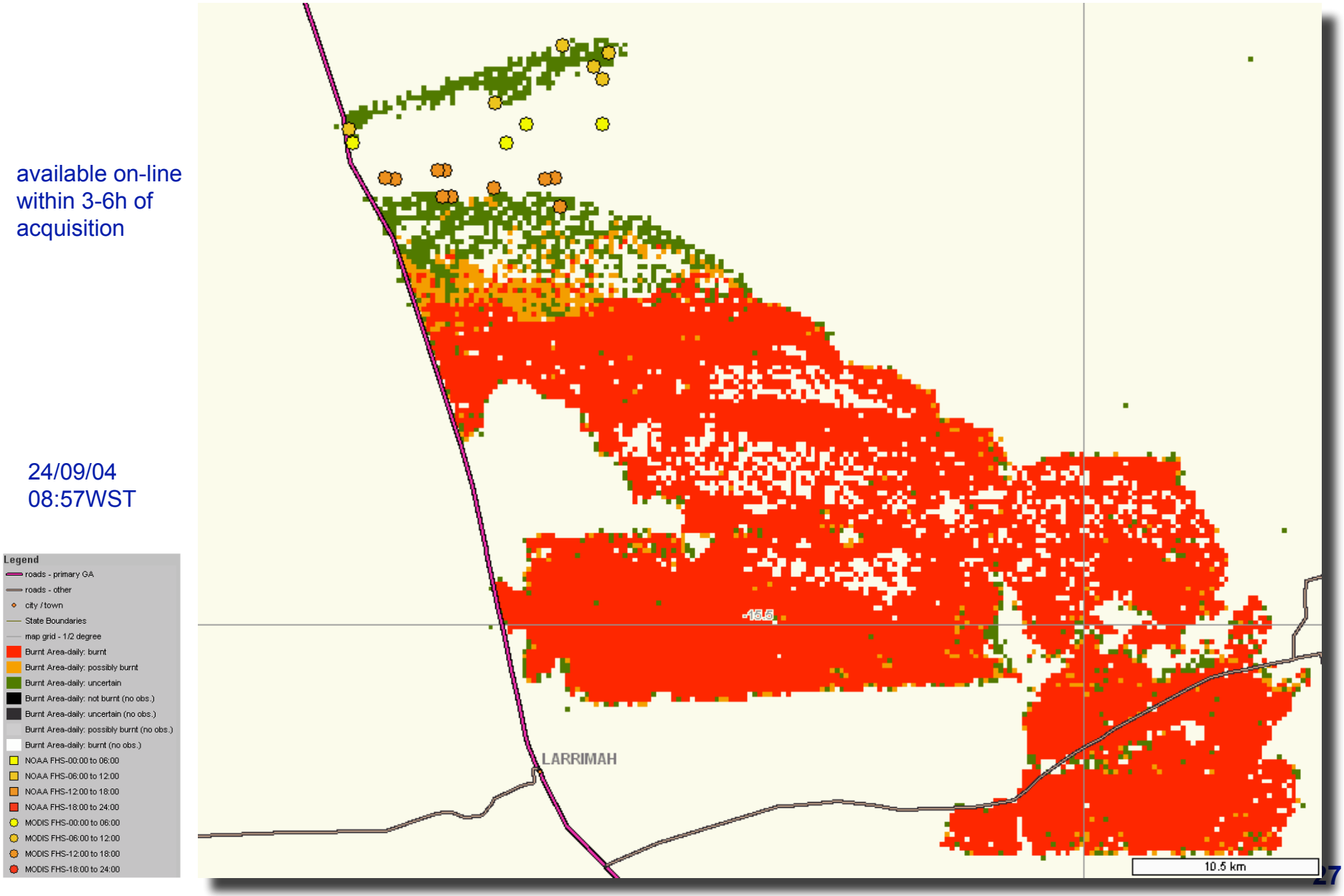
available on-line within 1h of acquisition



Near Real Time Daily Burnt Area Maps

available on-line within 3-6h of acquisition

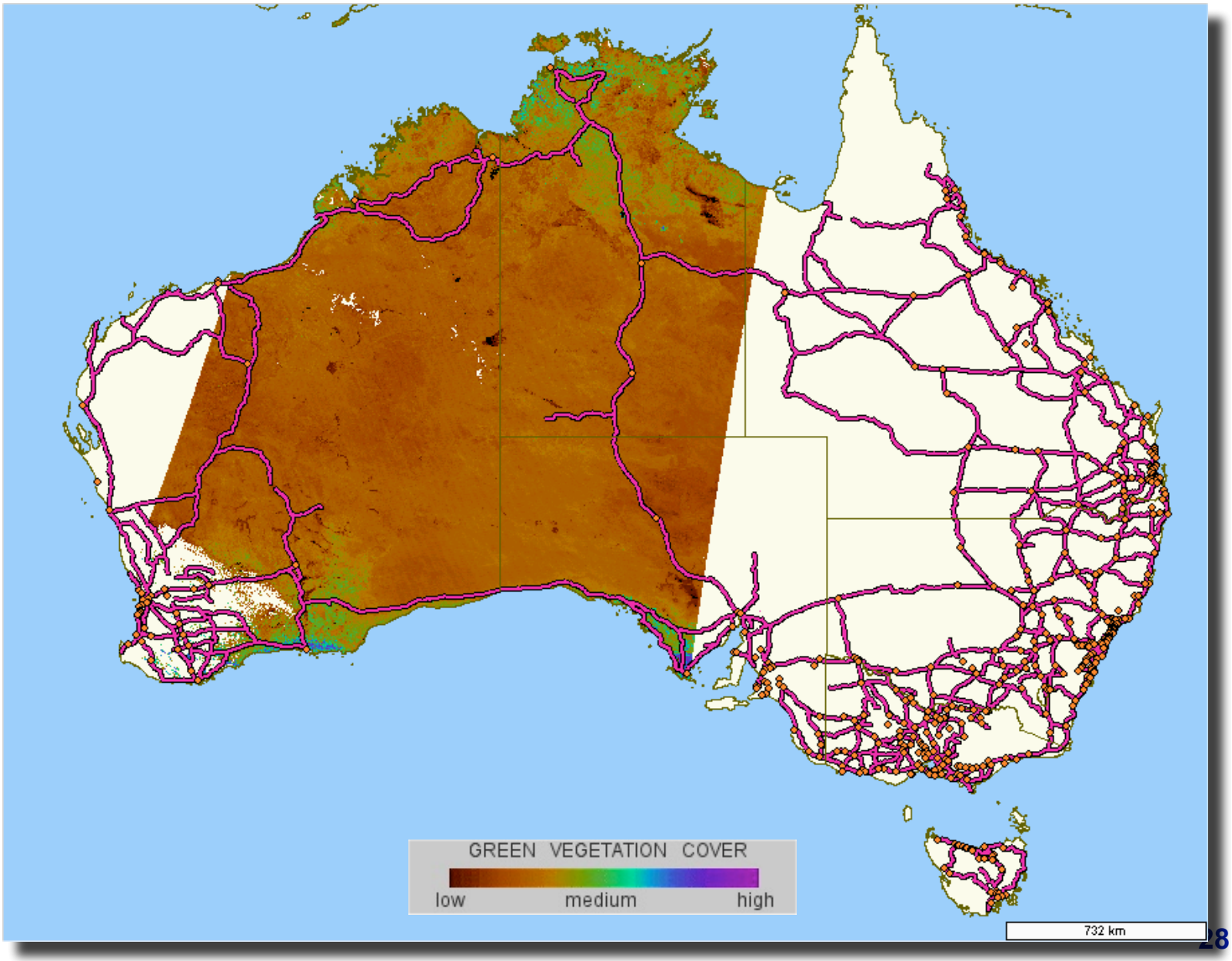
24/09/04
08:57WST



Near Real Time NDVI Maps (DAILY)

available on-line within 2h of acquisition

2 different stretches



11/10/04
09:35WST

Córdoba Ground Station. (ETC – CETT)

Córdoba Ground Station started operations in 1997 with the reception of satellite data from Landsat 5, ERS 1/2 and SPOT

Today the Station acquires data from more than 15 satellites and delivers an average of 1000 high level products per month.

CONAE
CETT- September-28-2005

Application:
Weather Forecasting

EOS DB Products Provided to NWS by NASA MSFC

The Short-term Prediction Research and Transition (SPoRT) Center at NASA MSFC applies EOS measurements and Earth science research to improve the accuracy of short-term (0-24 hr) weather prediction at the regional and local scale.

MODIS and AMSR-E products are provided to 6 NWS Forecast Offices in near real-time for analysis in AWIPS to address issues including:

- Convective initiation
- Morning minimum temperatures
- Fog and low cloud detection
- Sea/land breeze convection
- Coastal precipitation mapping

http://weather.msfc.nasa.gov/sport/

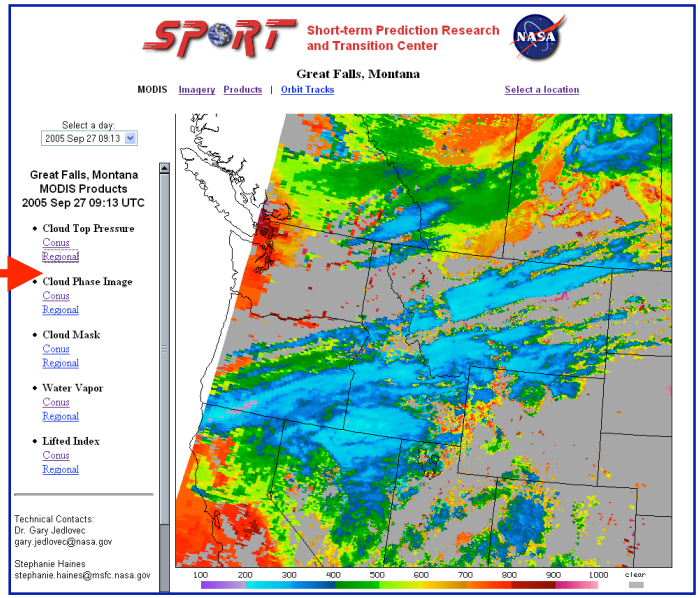
SPORT Products Provided to WFOs

MODIS products from Aqua and Terra:

- 4 times / day – 30-45 minutes latency
- 8-10 channels
- TPW, cloud mask, cloud height, stability

Level 1 radiances are used to generate additional products for WFOs:

- color composites
- cloud/fog products
- LST
- snow maps

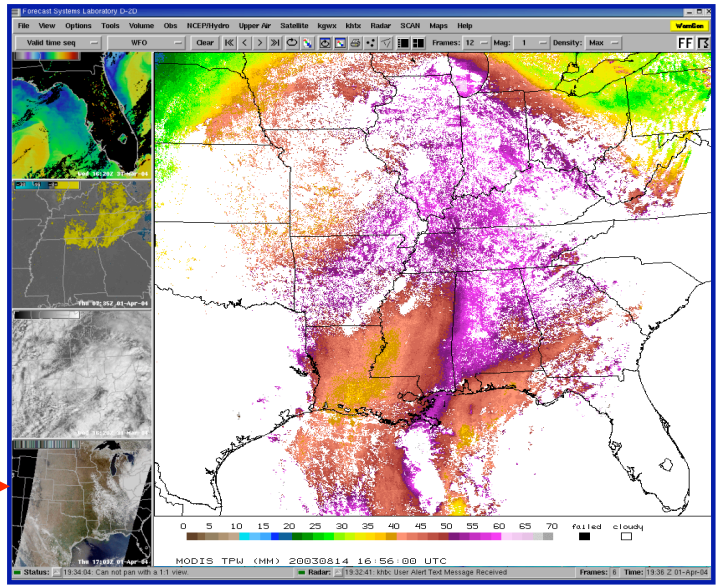


AMSR-E products to coastal offices:

- rain rate and convective fraction

Level 1 AMSR-E Tbbs are used to generate additional products over the ocean (TPW, ocean wind speed, SST)

All SPoRT data are provided in AWIPS

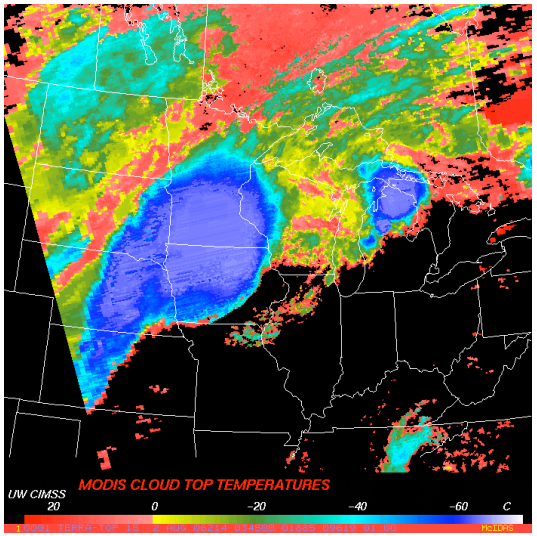


SSEC MODIS Products served to NWS

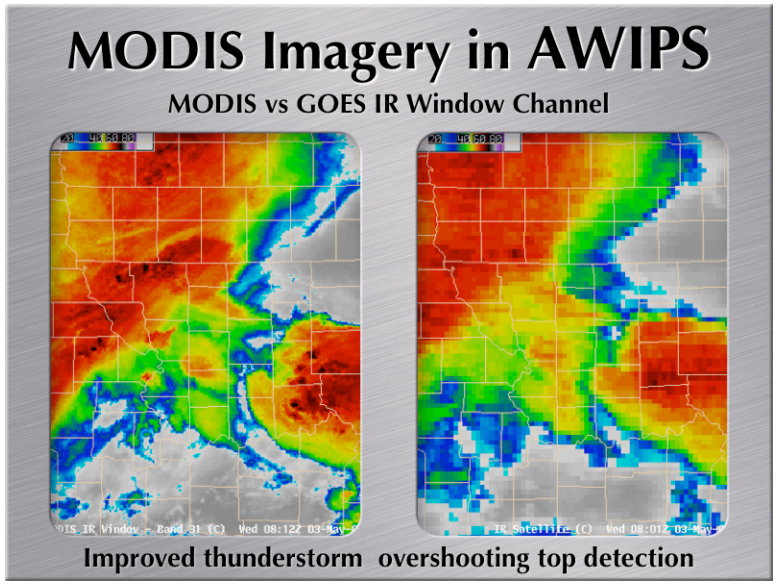
SSEC is working with NWS Lacrosse and Sullivan forecast offices to bring real-time MODIS products into daily operations.

SSEC began generating AWIPS compatible MODIS product images in near real-time in May 2006, and started routine insertion into the Central Region AWIPS data stream on 30 June 2006.

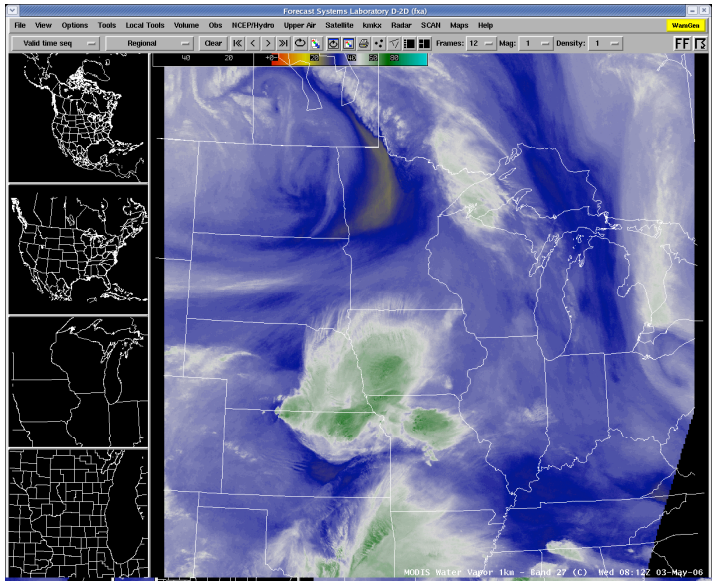
MODIS cloud top temperature over NWS WI forecast region



COMET training module for MODIS in AWIPS



MODIS water vapor channel in AWIPS

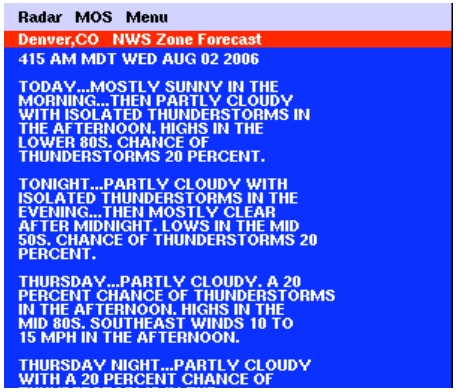


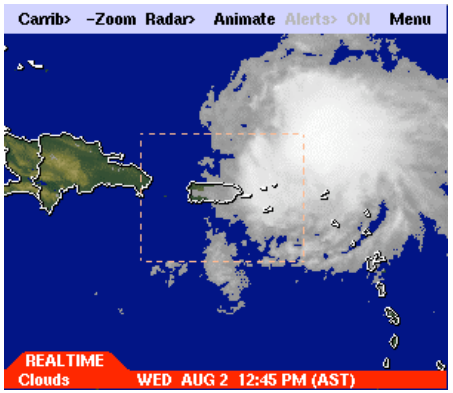
MODIS Real-Time Images for PDAs (Russ Dengel)

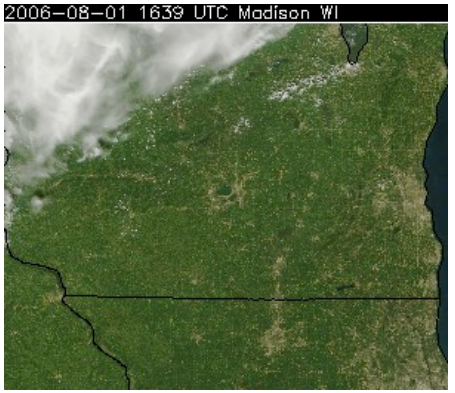
Satellite images, radar loops, forecasts, road conditions are reformatted for PDA size displays and made available in real-time.

MODIS True Color images are created from every daytime pass in PDA format; latest image is always available.

Users: Firefighters, Police, Pilots, Commuters…







www.ssec.wisc.edu/data/paw/

Application: Polar Winds

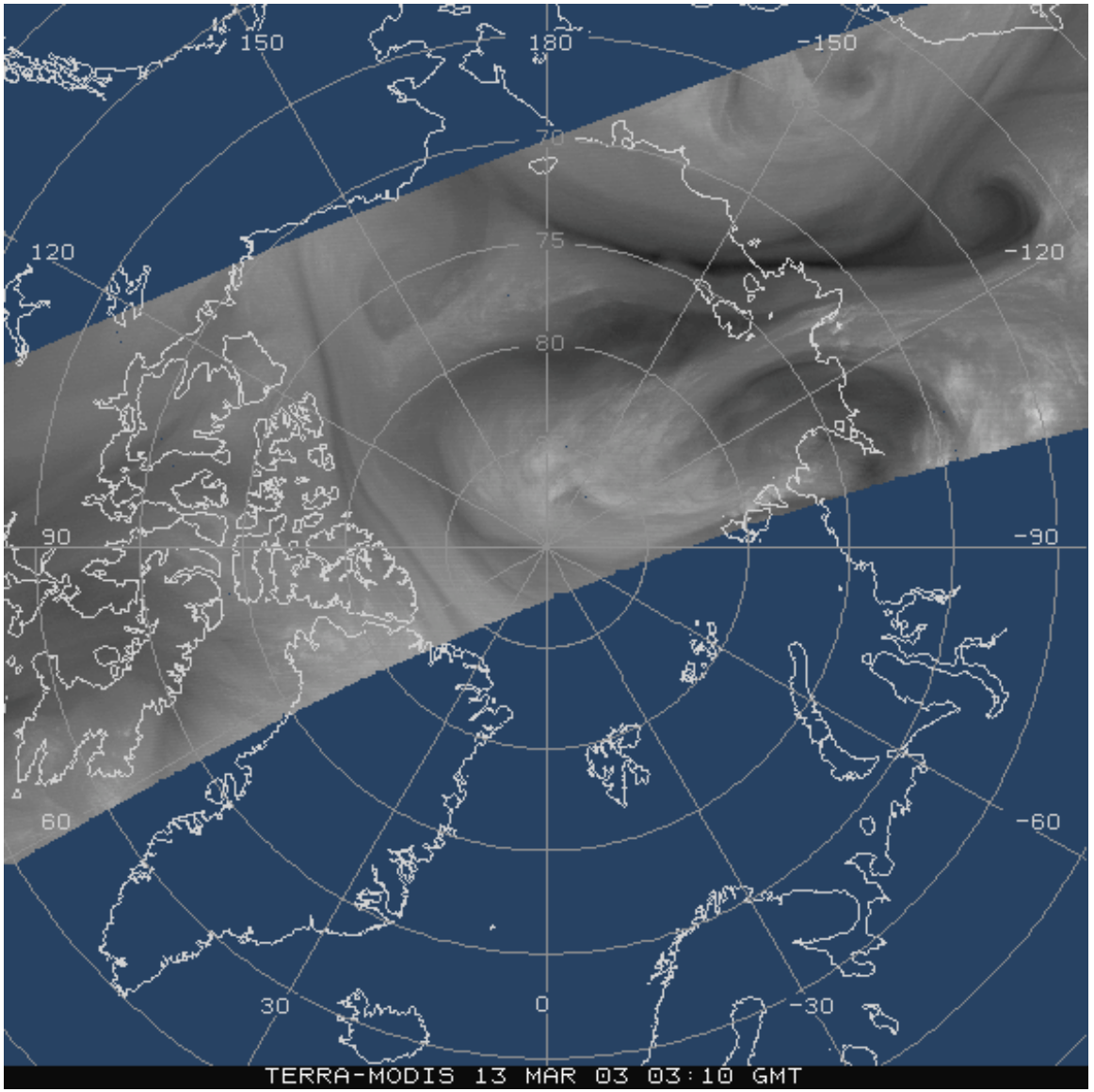
MODIS Passes over the Poles Allow Feature Tracking

Consecutive passes (100 minutes apart) depict atmospheric motion.

Band 27 (6.7 μm) tracks motion in troposphere (clear and cloudy).

Band 31 (11.0 μm) tracks cloud motions only.

Initial demonstration in 2002 used MODIS data from NOAA “bent pipe”.



Terra MODIS 6.7 μm (band 27) 2003/03/13

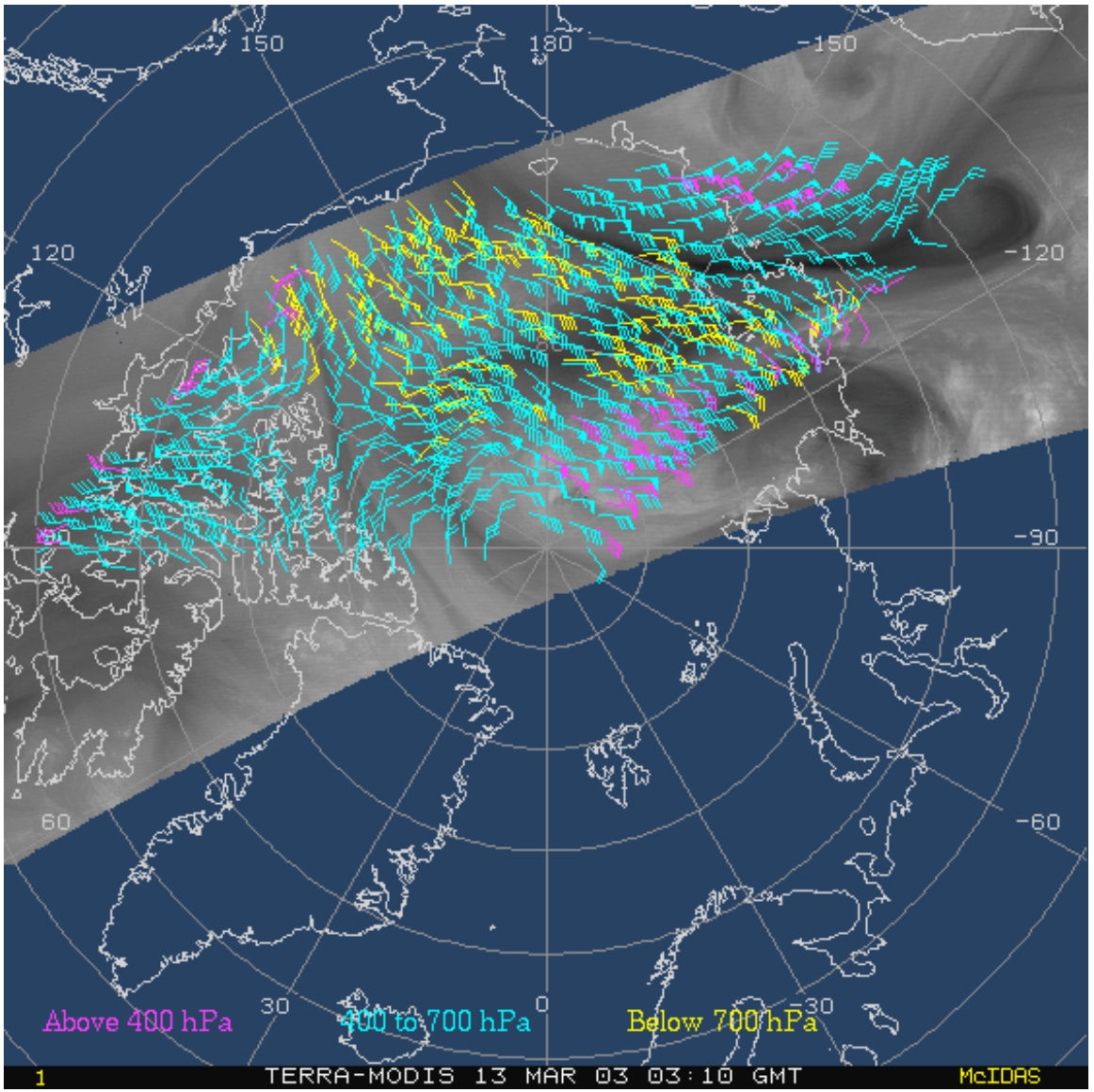
MODIS Polar Wind Vectors can be derived automatically

Wind vectors are generated using automatic feature tracking software developed for GOES.

6.7 μm heights are assigned based on forecast atmospheric profile.

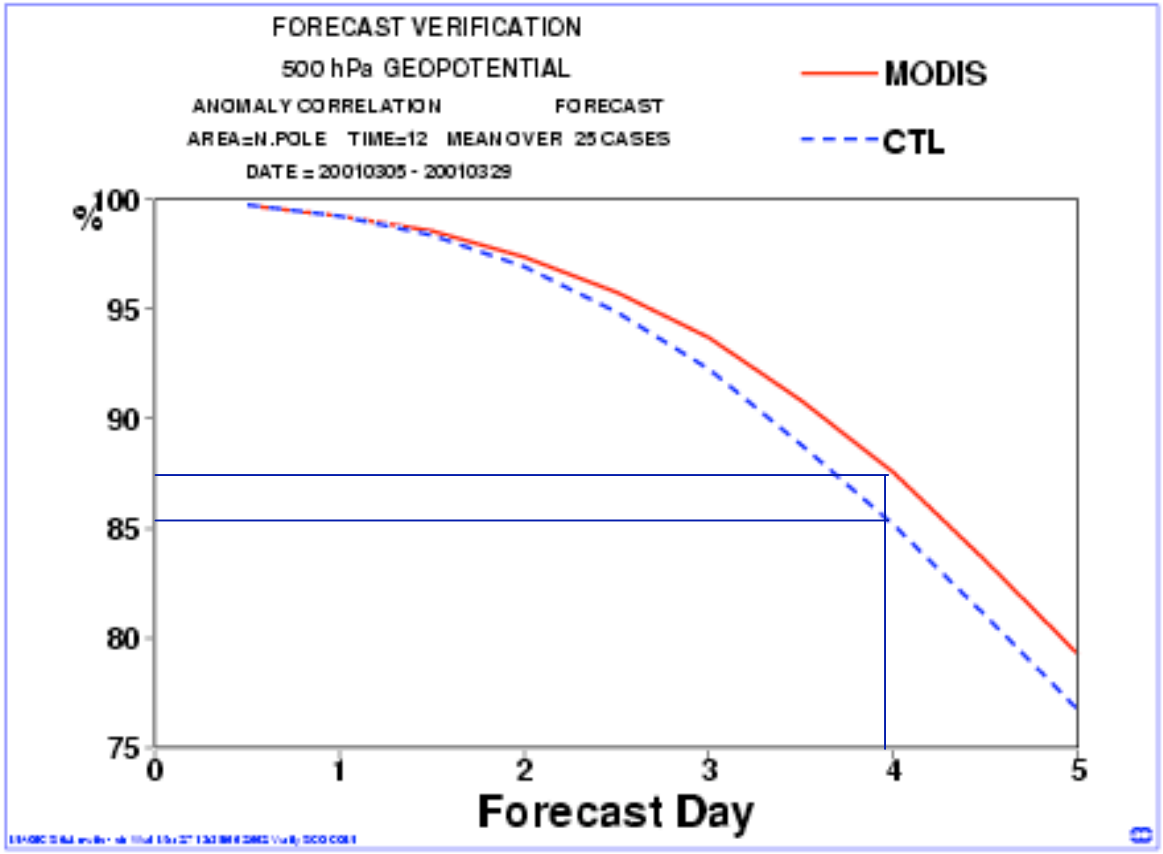
11.0 μm heights are assigned based on window brightness temperature or CO2 cloud height.

Winds are automatically quality controlled.



Terra MODIS 6.7 μm (band 27) 2003/03/13

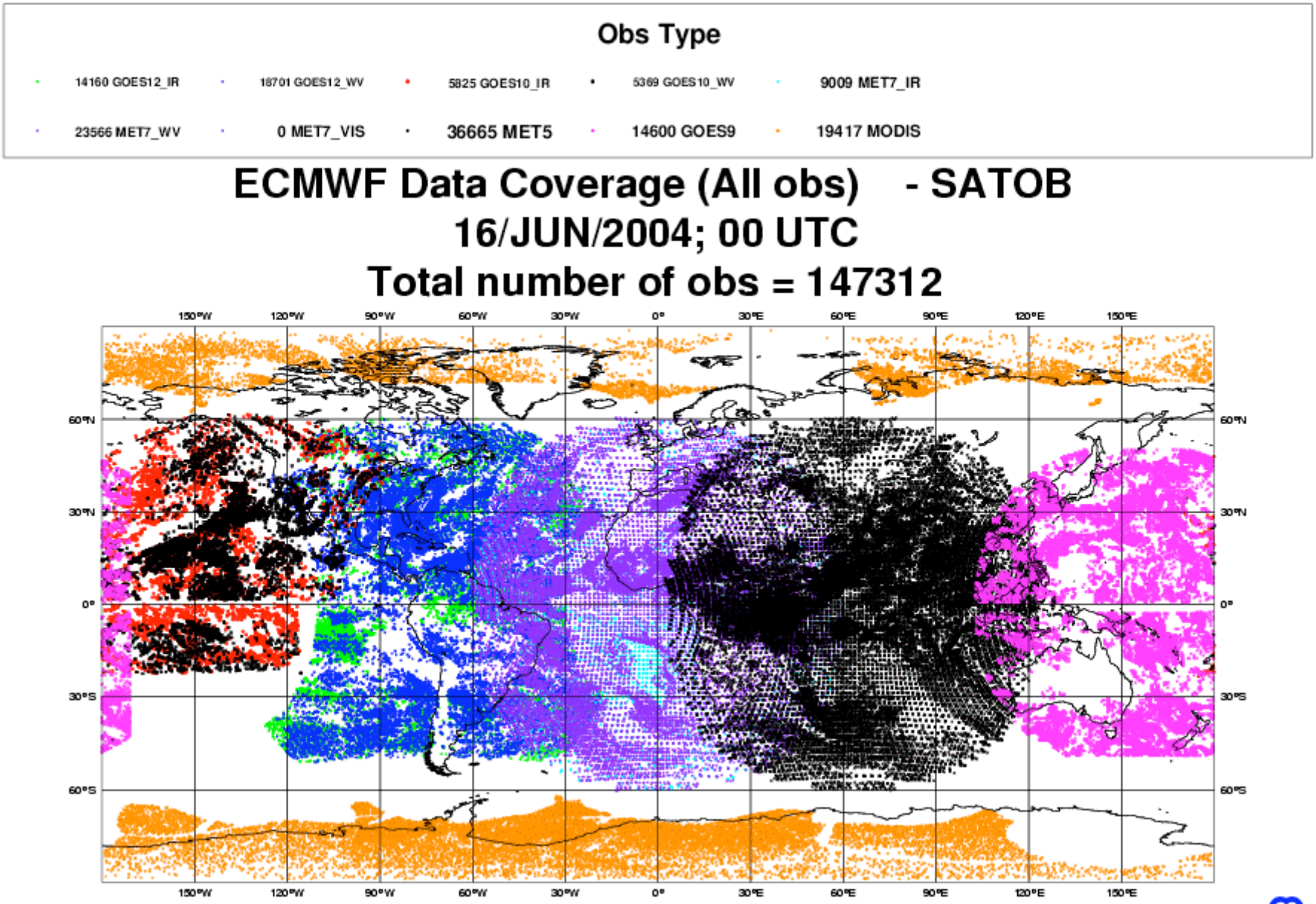
Positive impact on forecast demonstrated by ECMWF



NWP Centers using MODIS Polar Winds Operationally:

ECMWF, GMAO, JMA, CMC, FNMOC, UKMO, DWD, NCEP/EMC

MODIS polar winds are filling observing system void



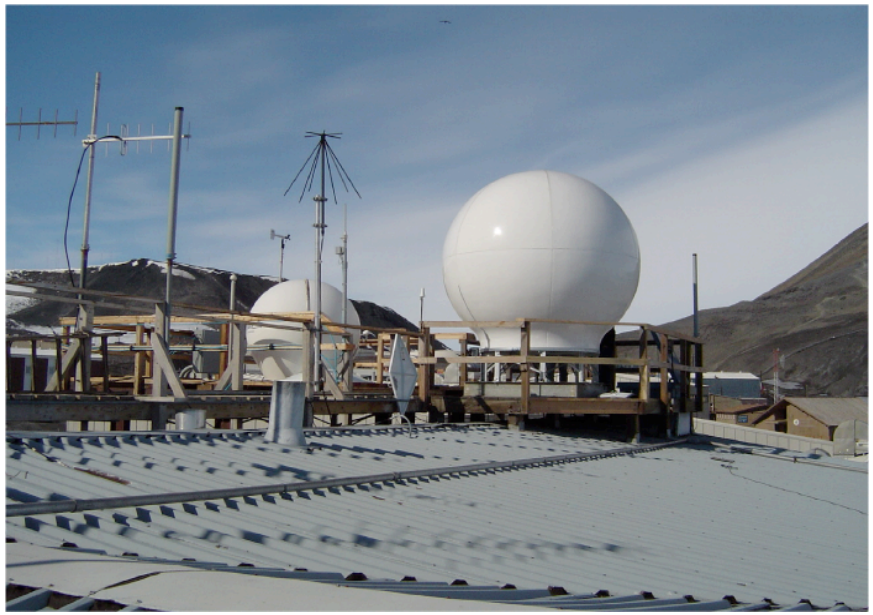
Problem: Latency in Data Available from Bent Pipe

MODIS winds from NOAA “Bent Pipe” system do not meet 3 hour cut-off time for regional/limited area data assimilation systems due to latency in NOAA “Bent Pipe” data feed.

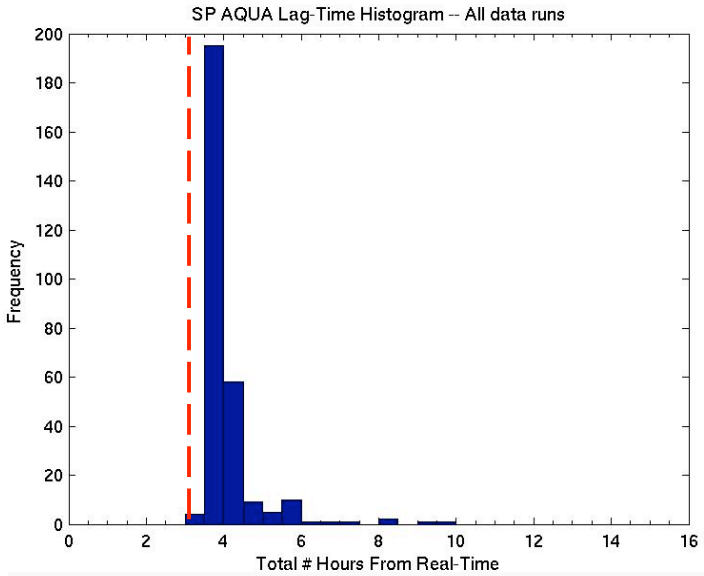
Solution: Direct broadcast high-latitude X-band stations

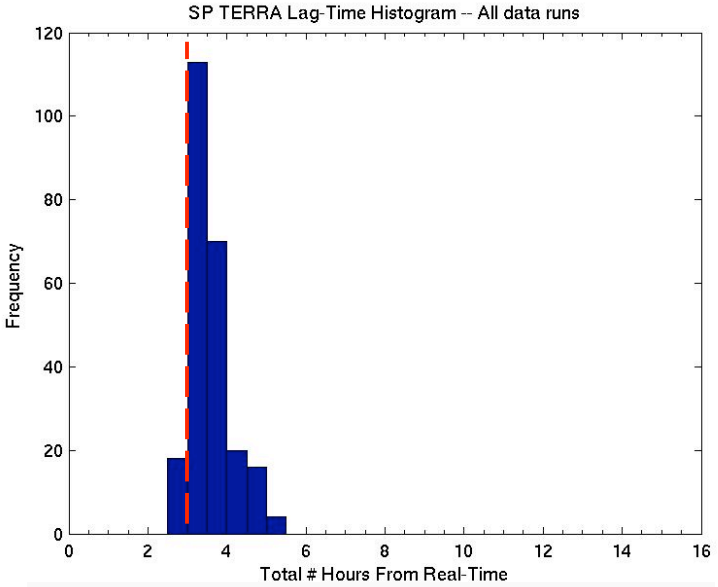
Northern Hemisphere:
Svalbard (KSAT)

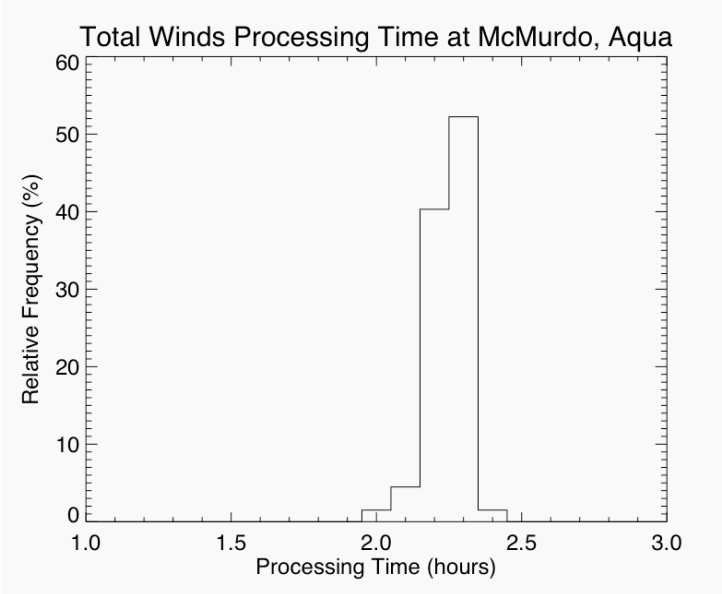
Southern Hemisphere:
McMurdo (NSF)

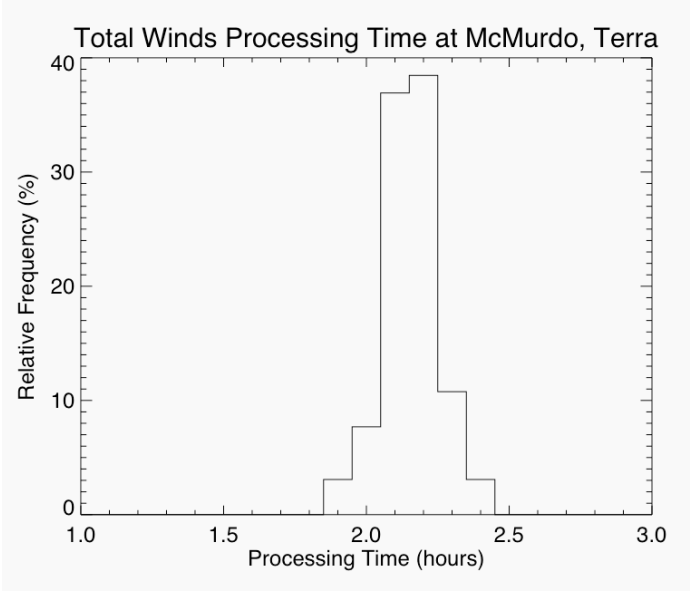


Direct Broadcast Winds Improve Latency to less than 3 hours









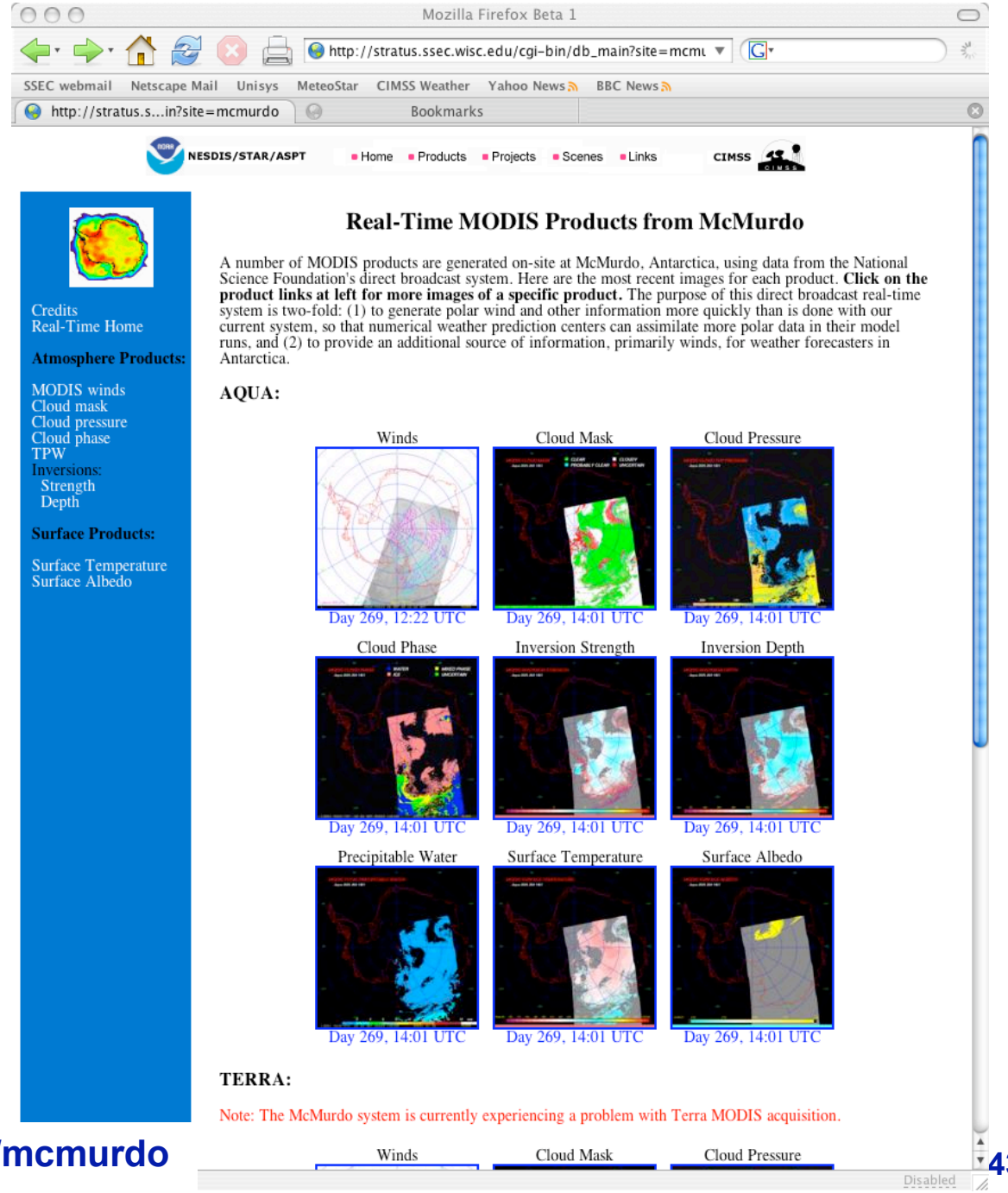
Processing times are for the middle image in a 3-orbit triplet. Actually processing time from image acquisition to availability of wind vectors is 100 minutes (1.67 hrs) less than shown. MODIS images are available (image acquisition to level 1b) in 20-30 minutes. Winds processing takes an additional 10-15 minutes.

Current Products at McMurdo (all MODIS):
Winds
Cloud mask*
Cloud pressure*
Cloud phase*
Total precipitable water*
Inversion strength
Inversion depth
Ice/snow surface temperature
Ice/snow albedo

Planned products:
Ice motion (MODIS + AMSR-E)
Ice age
Cloud optical properties

**http://stratus.ssec.wisc.edu/db/mcmurdo*

IMAPP/MODIS Science Team products



Summary

Aqua and Terra Direct Broadcast ground stations are running operationally on every continent (including Antarctica).

More than 150 stations around the world are acquiring, processing, and distributing products to local consumers.

Unencrypted data, open formats, and freely available processing software have contributed to the widespread adoption of EOS DB data.

National agencies are using EOS DB products for real-time operational decision support.

With support from NOAA Integrated Program Office, support for the DB community will continue into the NPP/NPOESS era.